Effects of task-specific training on walking and sit-to-stand after total hip replacement

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Twenty subjects with total hip replacement (THR) who were still experiencing movement problems at an average of 12.7 months post-operation undertook a six week outpatient program based on task-specific training of functional activities. All subjects demonstrated improved performance of walking and sit-to-stand after the training period. Specifically, scores on the ratings of occurrence of critical biomechanical components of the two tasks increased. In addition, step lengths of both legs, stride length and peak weight on the side of the most recent THR during the extension phase of sit-to-stand all improved significantly. This descriptive study suggests that task-specific training may assist individuals to improve performance of walking and sit-to-stand even if undertaken many months after a THR.

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In individuals with hip joint failure, the most important reasons for wanting a total hip replacement (THR) are the presence of day pain and difficulties with walking and participating in recreational activities (Wright et al 1994). Subsequent to being listed for surgery, patients have high expectations of their THR and the impact they feel it will have on their life.

Both favourable and non-favourable aspects of outcome have been reported following THR. Some studies report that patients experience relief of pain and improved functional capacity (Aarons et al 1996, Levy et al 1995, Wicklund and Romanus 1991). However, there is also evidence that weakness in the operated leg persists (Long et al 1993, Murray et al 1975, Shih et al 1994) and there is some evidence of mechanical dysfunction in the non-operated leg (Loizeau et al 1995). Following a THR, patients typically demonstrate decreased preferred walking velocity and shortened stride length (Brander et al 1994, Loizeau et al 1995). Murray and colleagues (1975) also found that pain, hip flexion contracture and need for assistive walking devices can still limit function in patients two years after THR.

Physiotherapy during the acute post-operative period is aimed at preventing complications which might arise from the surgical procedure and from the subsequent bed rest. The patient is usually encouraged to commence lower limb range of motion exercises and some form of assisted walking within a few days of surgery (Aarons et al 1996, Brander et al 1994, Brander et al 1995, Gogia et al 1994). However, it is during this acute period that recovery also occurs as a result of the natural healing process, so thereafter it is difficult to unambiguously attribute any gains in function to the use of physiotherapy.

Individuals with movement problems remaining months after the THR may be given further physiotherapy intervention. Such outpatient physiotherapy has typically continued lower limb range of motion and strengthening exercises, and general walking practice, also used in the period. It is generally assumed that improvements in hip muscle strength, range of motion and assisted walking will carry over into improved performance of functional tasks such as walking.

Several studies have reported increases in cadence and velocity of walking following participation in physiotherapy (Henderson et al 1992, Johnsson et al 1988, Patterson et al 1995, Sashika et al 1996). However, increasing cadence rather than increasing step length to improve velocity may be due to general benefits of the THR such as decreased pain, but not to improved strength and control of the operated leg. Therefore, it is important to determine whether improvement in performance of tasks such as walking and sit-to-stand is associated with improvement in performance of critical biomechanical components of these tasks, or simply due to patients becoming more skilled at using their pre-operative movement patterns or any adaptive behaviours which they may develop post-operatively.

Carr and Shepherd (1991) have proposed that, in order to achieve optimal improvement in performance of functional tasks like walking and sit-to-stand, patients need to practise exercises which approximate these tasks as closely as possible, rather than undertake only exercise designed to improve strength of isolated muscle groups and increase passive joint range of motion. Further, they argue that physiotherapists should assess patients during their initial attempts at these tasks in order to identify any deficiencies in the critical biomechanical components, so these can be specifically addressed in selection of training exercises. The aim of this study was to investigate the effects of a six week program of task-specific training of walking and sit-to-stand in individuals following THR. Specifically, we sought to investigate whether occurrence of the critical biomechanical components of the two tasks would be increased after training.

Table 1. Subject characteristics

Gender	11	male
	9	female
Age (years)	66.7	mean
	7.8	SD
Time since most recent THR (months)	12.7	mean
	9.7	SD
Side of most recent THR	12	right
	8	left
Surgical approach	15	lateral
	5	posterior
Nature of prosthesis	17	uncemented
	3	cemented
Previous THR on contralateral hip	16	no
	4	yes
Revision of THR	15	no
	5	yes
Use of stick	6	outdoors
	5	always

Table 2. Descriptive statistics of the changes in step length, stride length, preferred walking velocity and peak weight on most recently operated leg during sit-to-stand.

	Before training Mean (SD)	After training Mean (SD)
Step length (m)		
operated leg	0.52 (0.11)	0.60 (0.12) *
non-operated leg	0.52 (0.10)	0.61 (0.10) *
Stride length (m)	1.05 (0.21)	1.20 (0.21) *
Preferred walking velocity (m/s)	1.07 (0.27)	1.15 (0.19)
Peak weight on the operated leg during sit-to-stand (% body weight)	29.26 (13.73)	43.66 (4.60)*

* denotes statistically significant change.

Method

Subjects

Hospital records of patients with THR from July 1, 1991 to December 31, 1993 were reviewed after approval by the executives of two local surgical hospitals, Dudley Private Hospital and Orange Base Hospital. Subjects were included if they could walk independently, with or without a stick, and had not undertaken outpatient physiotherapy since their most recent THR. Subjects were excluded if they had neurological deficits, dementia or previous lower limb fractures. Seventeen subjects were contacted by telephone. Two individuals who were referred by other health professionals and one individual who requested involvement in the study after hearing about the program also met the inclusion criteria and joined the study, giving a total of 20 subjects (Table 1). All procedures were conducted in accordance with Orange Base Hospital ethical guidelines.

This was a descriptive study in which performance of walking and sit-to-stand were measured before and after a six week program of task-specific

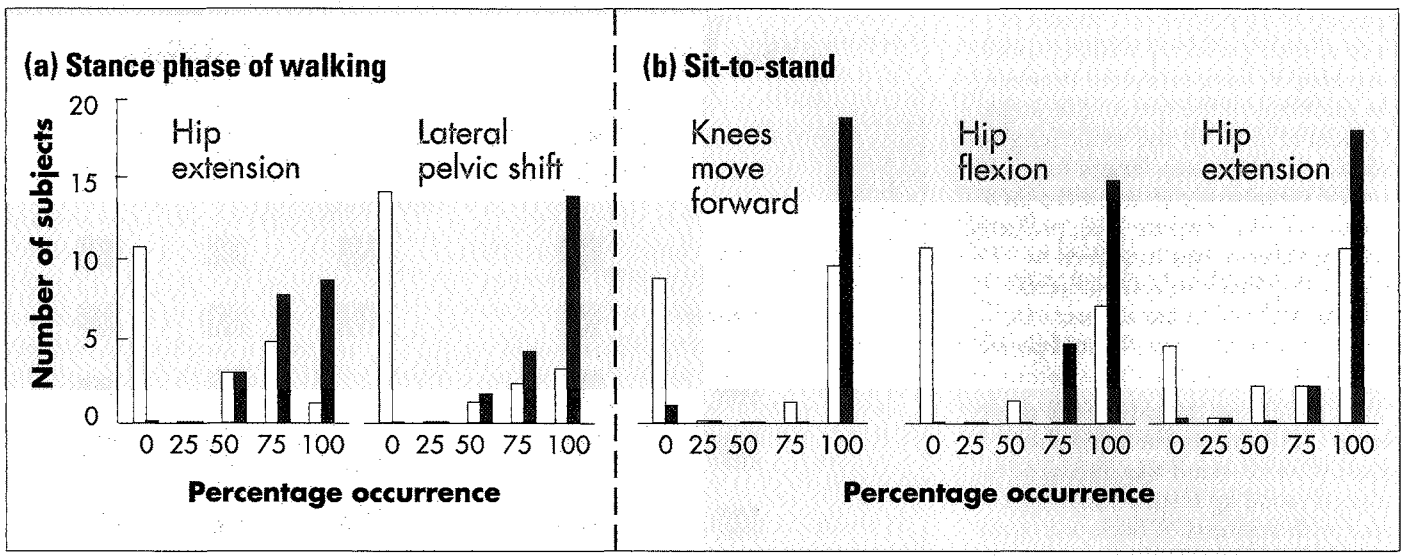

Figure 1. Number of subjects rated as demonstrating 0, 25, 50, 75 or 100 per cent occurrence of the critical components of (a) walking and (b) sit-to-stand. Unfilled columns - before training; shaded columns - after training.

training. The subjects attended the physiotherapy department of the Orange Base Hospital for training and measurement sessions.

Training program

Subjects attended the outpatient physiotherapy department for training with a physiotherapist. Training of walking and sit-to-stand was based on the motor learning model for rehabilitation developed by Carr and Shepherd (1987). Walking and sit-to-stand abilities were analysed by observation of performance and comparison with known models for each task. Missing or deficient critical biomechanical components of each task were identified, then subjects were instructed in an individually tailored program of exercises designed to improve performance of those components. Exercises designed to increase the strength and control of weak muscles and to increase soft tissue flexibility were performed in contexts appropriate to the tasks being trained. Where possible, subjects practised the whole task, but where this was not possible due to motor impairment, subjects initially practised components of the task, then progressed to whole task practice as performance improved (Carr and Shepherd 1987a and 1987b). Subjects attended at weekly or two weekly intervals for a half to one hour session. Duration and frequency of training sessions varied between subjects and depended on the number of components that needed training and the subject's ability to learn to monitor their own performance and practise on their own.

Subjects also completed structured, self-monitored practice in their own homes. They were asked to practise every day and to record the number of repetitions of each exercise performed. The exercises were the same as those practised during training with the physiotherapist, and the number of repetitions was set within the limits of fatigue. The record of self-monitored practice was checked when subjects visited the physiotherapist, and exercises and repetitions were progressed as performance improved. All analysis and training were conducted by the first two authors.

Assessment procedures

Performance of walking and sit-to-stand was assessed before and at the end of the training program. The occurrence of critical components was assessed by observation of the subjects walking 20 metres and standing up three times from a 52cm high chair. The critical components observed were hip extension and lateral pelvic shift during stance phase of walking and knee movement forward, hip flexion and hip extension during sit-to-stand (Carr and Shepherd 1987a). Occurrence of each component was rated as 0 per cent (never present), 100 per cent (always present) or 25, 50 or 75 per cent (if partially or inconsistently present). Observations were made by the first two authors, both of whom had previously demonstrated reliability in using the Motor Assessment Scale (Carr et al 1985), a scale on which performance on everyday tasks is scored from observation[¶]. The criteria for scoring walking and sit-to-stand include noting the presence or absence of the critical components used in the current study.

Procedures used in clinical practice were used to measure the following dependent variables: bilateral step length, stride length, preferred walking velocity and peak weight on the side of the most recent THR during the extension phase of sit-to-stand. Non-permanent markers were taped to the subjects' heels and subjects walked a

distance of 10 metres on a linoleum floor at their preferred walking speed. Step lengths were measured between the markings of the five middle steps (Gaudet et al 1990) and stride lengths calculated. Mean step length for each leg and mean stride length were then calculated. In a separate trial, preferred walking velocity was measured by using a stopwatch to time subjects walking without an aid at their preferred velocity over the middle 10 metres of a 20m path.

Peak weight on the side of the most recent THR during the extension phase of sit-to-stand was measured as subjects stood up from a 52cm high chair with armrests. A bathroom scale with digital readout on a handpiece was placed under the most recently operated leg and a step of equal height under the other leg. A pressure sensitive switch was placed on the seat under the subject's thighs. When the thighs were lifted from the seat, the switch was activated and a buzzer sounded. Use of hands to push up was discouraged, but if subjects were unable to stand without the use of their hands, it was permitted. Peak weight was defined as the maximum weight displayed on the readout after the seat switch buzzer sounded as the subjects were standing up. Subjects performed three trials and the highest reading of the three trials was recorded. To enable comparison between subjects, peak weight is presented as a percentage of total body weight.

Statistical analysis

Ratings of the occurrence of the critical components were graphed and analysed using Wilcoxon matched pairs signed ranks. Mean step and stride lengths, preferred walking velocity and peak weight on the side of the most recent THR were analysed using two tailed, paired *t*-tests. An alpha level of 0.01 was used in all analyses.

Results

The rated occurrence of each of the critical components increased significantly: stance phase hip extension ($p < 0.001$), stance phas

Figure 2. Single subject data for rating of occurrence of critical components of (a) walking and (b) sit-to-stand. Each block represents an increment of 25 per cent hence, 4 blocks in a column indicates a rating of 100 per cent. Unfilled columns - before training; shaded columns - after training.

lateral pelvic shift ($p < 0.001$), sit-to-stand knees move forward ($p = 0.004$), sit-to-stand hip flexion ($p = 0.001$) and sit-to-stand hip extension ($p = 0.006$) (Figure 1). All except two subjects, Subjects 3 and 12, increased their score on every component where the rating was less than 100 per cent before training (Figure 2).

Step lengths of both legs, stride length and peak weight had all improved significantly after the training ($p < 0.001$, Table 2). Preferred walking velocity increased but the increase was small (less than 10 per cent of the pre-training mean) and approached, but did not reach, statistical significance ($t = 1.79$, $p = 0.09$).

Discussion

The findings of this study clearly indicate that after the training period, subjects had improved their performance of both walking and sit-to-stand. When training commenced, subjects were, on average, 12 months post-THR and continuing to demonstrate weakness and mechanical dysfunction on the side of the most recent THR during performance of both tasks. During training, they practised exercises to improve performance of the critical components of the two tasks. Rather than using a standardised battery of exercises, the exercises for each subject were selected according to which components of the two tasks were deficient when the physiotherapist observed the subject's performance. For example, Subject 5 (Figure 2) practised exercises to improve hip flexion and knee movement forward during sit-to-stand, whereas Subject 20 practised exercises to increase hip extension during both walking and sit-to-stand.

After the training period, subjects demonstrated increased rating of occurrence of the critical components of the two tasks. While there is some potential for observer bias on the checklist, since the same physiotherapists performed both assessment and training, the improvements noted on the checklist are consistent with the improvements recorded with the objective measures suggesting that the threat from observer bias is likely to be small. Reliability of using the middle scores on the observation rating (25, 50 and 75 per cent) is, as yet, unevaluated but the trend for rated occurrence to approach 100 per cent on all components is evident in Figure 2.

The increased consistency in performance of the critical components after the training period may well underlie the improvements in the other measures. For example, control of hip extension and lateral pelvic shift during the stance phase of walking are likely to promote increased step length, and improved control of hip extension on the operated side is likely to contribute to increased step length on the non-operated side. Similarly, improved hip flexion and extension during sit-to-stand indicates improving hip control and is likely to allow increased weight to be borne on that side during the extension phase.

The effect of training on walking velocity is not clear. Preferred velocity before training commenced was within limits reported for healthy adults aged 63 years or more walking at self-selected normal speeds (Himann et al 1988) and therefore may have been subject to a ceiling effect. In future research with this patient group, measurement of a fast self-selected speed (SSS) of walking rather than the subject's preferred velocity may provide a more sensitive measure of the effect of training. Fransen et al (1994) suggest that a fast SSS is a more appropriate indicator of gait dysfunction than a slow SSS using the parameters of velocity and stride length.

In addition to improved performance of the two tasks, subjects were also noted to decrease use of adaptive behaviours evident before training commenced. For example, the majority of subjects demonstrated decreased hip flexion during sit-to-stand, a deficit which may be due to subjects having been taught to place the foot of their operated leg forward prior to standing, to push up with their arms and to minimise weight shift to that side, in order to protect the operated hip. These adaptive behaviours become habitual unless individuals engage in activities designed to help them regain strength and control of the operated leg and are instructed that such adaptive behaviours are no longer necessary for effective function.

Comments made by the subjects after training finished support the contention that task-specific training had an impact on the most important reasons for subjects wanting a THR, ie presence of day pain and difficulties with walking and participating in recreational activities. Five subjects reported a reduction in pain and the number of subjects using a stick to assist walking decreased from 11 to six, only one of whom used a stick all the time. Three subjects reported that they had returned to previous recreational activities including golf and bowls. For example, one patient who previously played lawn bowls had been unable to return to the sport as he could not step down onto the green. After the training, this was not a difficulty and he resumed playing.

The extent to which the improvements in walking, sit-to-stand and function can be attributed specifically to effects of the training program is not clear, given the lack of an untreated control group. However, spontaneous improvement of the order obtained here seems unlikely given the length of time post-surgery and the relatively short duration of the training program. For example, the increase in peak weight on the operated leg during sit-to-stand from 29 per cent to 44 per cent of body weight reported in the current study seems unlikely to be measurement error, even though the reliability of using digital scales in the manner described here has yet to be demonstrated. In future work it would be appropriate to measure the timing of the peak weight with respect to when the thighs are lifted off the seat, since taking most body weight on the stronger leg around the time of thighs-off is a common adaptive behaviour.

Conclusion

This descriptive study has shown that subjects with THR are able to improve performance of sit-to-stand and walking, even many months after surgery. It suggests that a program of task-specific training is likely to assist individuals to improve on both qualitative and quantitative measures of the two tasks and to improve function generally.

Footnote

¶ Information on the standardised procedure for testing reliability in using the MAS is available from the 3rd author, Virginia Fowler.

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